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SUMMARY

CCD photometry in the V band is presented for 7 field RR Lyrae stars selected from a sample of eight variables which, according to data collected in the literature, are expected to be *ab*-type pulsators, to have short periods and hence high metallicity, and to be located at high z from the galactic plane. New periods and epochs are derived for them. The new periods are only slightly shorter than the values published on the last edition of the General Catalog of Variable Stars (GCVS4). Instead, in six cases our amplitude of the light variation is significantly smaller than that published on the GCVS4, and in at least three cases the actual pulsation appears to be in the first harmonic rather than in the fundamental mode. All the suggested *c*-type pulsators show variations in the amplitude and/or quite scattered light curves. Possible explanations are given.

From a spectro-photometric analysis of the sample, only DL Com is confirmed to pulsate in the fundamental mode, to have short period, and to be located at relatively high z. A single object cannot be taken as evidence for a significant metal rich population at large distance from the galactic plane.

1. INTRODUCTION

RR Lyrae stars have early been recognized as very good tools to study the structure and the evolution of the Galaxy. Their pulsational properties, combined with their almost constant absolute magnitude, allow one to use them as tracers of the different stellar populations evolving in different galactic regions. It is well known, for instance, that the period distributions of field RR Lyrae variables depend on their galactic location (Preston 1959, Layden 1993). In particular, halo RR Lyraes of Bailey type *ab* show a peaked period-frequency distribution which is a mixture of those derived from variables located in Oostheroff I and II globular clusters, bulge RR Lyraes show the typical asymmetric histogram of Oosterhoff I clusters with no fundamental pulsators with period shorter than $P=0.45^d$, and disc RR Lyraes show instead a quite disperse distribution with many short period pulsators in the fundamental mode (Castellani et al. 1981). These different behaviours can be interpreted in terms of different stellar initial metallicity, since several authors (e.g. Lub 1977) have suggested an anticorrelation between period and metallicity in *ab*-type RR Lyraes. Such anticorrelation has been questioned by some other authors (Layden 1993 and references therein) because of the difficulty in reconciling a period-metallicity relation with the observed distribution of the parent non variable stars. Despite the large dispersion of the observational data, however, the dependence of the period on [Fe/H] is apparent also in their own data (see e.g. Layden's fig.6.4).

From a sample of 273 field RR Lyrae stars of Bailey type *ab* selected from the tape version of the third supplement to the third edition of the General Catalogue of Variable Stars (Kukarkin et al. 1976, hereinafter $GCVS_t$) with the requirement of having galactic latitude $|b| \geq \pm 45^o$, Castellani et al. (1983, hereinafter CMT) found that the minimum periods of RR*ab* increases with increasing height z on the galactic plane following the relation $\Delta log P_{min}/\Delta|z| = 0.004$ dex kpc^{-1}. Assuming Lub's (1977) anticorrelation between period and metallicity, they suggested that the period increase with height on the galactic plane corresponds to a metallicity gradient $\Delta[Fe/H]/\Delta|z| = -0.02$ dex kpc^{-1}. Both period and metallicity gradients with z are rather uncertain due to the large errors affecting the data, but there is no doubt (see also Layden 1993) that short period and metal rich variables are concentrated within less than 1 kpc from the galactic plane, whereas long period and metal poor variables have no apparent concentration and reach quite large z.

However, CMT found a few variables deviating from the overall z-period distribution, since they showed periods quite shorter than all the others at z up

to almost 10 kpc. If confirmed, short periods at large heights on the plane would imply that metal rich stars can reach large distances from the thin disc and that the thick disc is several kpc wide. On the other hand, apart from RS Boo for which accurate B,V,K light curves have been published by Jones et al. (1988), these *anomalous* pulsators have generally very poor photographic light curves (see for instance Kurochkin 1961, Meinunger & Wenzel 1968) and therefore their periods and magnitudes (i.e. distances) are quite uncertain.

In order to examine in more detail these deviating stars (namely: RS Bootis, AT Comae, BE Comae, BS Comae, CU Comae, CY Comae, DL Comae and CM Leonis), and the related question of metal rich objects at large distances from the galactic plane, we have observed them for several years, deriving accurate V light curves and periods from the photometric data. To obtain also direct estimates of their metallicities we have taken some spectra at minimum light and applied the method described by Clementini et al. (1991) to infer [Fe/H] from the equivalent width of the calcium K-line.

The data acquisition and reduction are described in the next section. The derived features of each variable are described in Section 3 and the overall conclusions are discussed and summarized in Section 4.

2. THE DATA

2.1 Data Acquisition

All the observations have been carried out at the 1.52 m telescope in Loiano operated by the Bologna Observatory and equipped with an RCA CCD with $4.3' \times 2.7'$ field of view and a 0.5 arcsec pixel scale, or with the BFOSC system.

BFOSC (Bologna Faint Object Spectrograph & Camera) is a focal reducer-type spectrograph/camera similar in concept to ESO's EFOSC 1 and 2. The instrument offers the possibility to switch from direct imaging to spectroscopy in less than one minute. The detector presently installed on BFOSC is a Thomson 1k×1k CCD giving a field of view of $9.6' \times 9.6'$. The pixel scale is 0.56 arcsec.

Finding charts for the variables observed with CCDs are shown in Fig.1, where the variable stars are marked by dashes, and the comparison stars by their identification names (see Table 2). Each chart shows a region of the sky of $10' \times 10'$. Since the purpose of our photometric observations was to obtain accurate light curves to improve periods, epochs and mean apparent visual magnitudes (and hence distances) of the program stars, in general we only took V exposures of our

targets. The variables are all located toward the North Galactic Pole, therefore they are observable from late January through early June. Photometric data have been acquired in the Johnson's V band during 48 nights from early 1989 through mid 1994, with no observations in 1991 for a telescope breakdown. The number of CCD images taken for each star ranges between a minimum of 68 for BE Com and a maximum of 177 for CY Com. A few R and I exposures were also obtained for one of our objects, namely CU Com. In Table 1 we summarize coordinates (Columns 2 and 3), number of observations (Column 4), and observed time interval (Column 5), for each variable.

UBVRI observations of RS Boo were obtained at the same telescope but with a photoelectric photometer and will be analysed elsewhere (Clementini et al. 1995).

To guarantee a reliable differential measure of the magnitude variability of our RR Lyrae stars, each CCD field includes at least a couple of other (hopefully stable) stars with magnitude comparable to that of the variable. Coordinates and derived V magnitudes of the primary comparison stars are listed in Table 2. Column 2 gives the number of the star according to the Hubble Space Telescope Guide Star Catalogue (GSC). The first four digits identify the GSC region which contains the star and the last four digits identify the star within the region.

To calibrate our photometry 18 primary standard stars taken from Landolt (1982, 1993) and covering a wide range of B−V colours have been observed with the Johnson's V filter at various air masses and in several photometric nights. The photoelectric V magnitudes and B−V colours of the observed calibrators are listed in Table 3.

Spectra have been taken for our candidate RR*ab* variables (except RS Bootis which was already available) in the spring 1994 when the light curves, and therefore the epochs of minimum light, were already well defined. As a further test, direct images of the objects were taken just before and after the spectrum exposure to check the exact location of the spectral observation in the light curve. However, only BS Com turned out to be bright enough to allow a sufficient measure of the equivalent width of the calcium K-line with the 1.52 m telescope and the presently available instrumental configuration, and with exposure times short enough (≤ 45 min) to remain in the range of minimum light phases.

2.2 Data Reduction

All the data have been reduced in the IRAF[1] environment, including debiassing

[1]IRAF is distributed by National Optical Astronomy Observatories, operated

and flat fielding. On each CCD frame, we have measured the instrumental magnitude of the variable stars and of at least two comparison stars in order to derive the light curve of each variable in terms of differential magnitudes, and sensibly reduce the uncertainty on our results due to the atmospheric and local conditions. Only the field around AT Com does not contain more than one reliable comparison star. Thanks to the isolated location of our targets, the instrumental magnitudes of all our images have been derived by direct photon counting with aperture photometry, taking into account the image profiles by means of APPHOT. Images on the same CCD frame have all been treated with the same aperture radius to guarantee the consistency of the magnitude derived for the variable star with those of the comparison stars.

The standard calibrating stars have been measured exactly in the same way. Extinction coefficients for the photometric nights were derived from observations at various air masses of both the standard stars and the comparison stars of the program variables. The derived V atmospheric extinction ranges between 0.29 and 0.47 mag, in good agreement with other photoelectric determinations of the seasonal mean extinction of the site. The conversion of our instrumental magnitudes v to the Johnson standard system is given by:

$V = 0.995v - 7.772$ (a) and $V = 0.971v - 4.956$ (b),

for the RCA and BFOSC instrumental magnitudes respectively. Calibration (a) is shown in Fig.2.

Since our photometry has been obtained with two different CCDs and instrumental set-ups, we have carefully checked the consistency of the calibrations resulting for the same stars with the two systems. No appreciable difference has been found between the two calibrations and between different calibration nights. In fact, except for AT Com, the magnitudes attributed to the various comparison stars by the different calibrating systems and/or in different observing nights, agree with each other within $\pm$ 0.03 mag. This can be considered the uncertainty in the zero point of our photometry.

As a further check of the quality of our photometry and to verify the constancy of the comparison stars, their magnitudes have been monitored through all the years of observations and turned out to be stable within ± 0.03 mag. There is some suspect that the comparison star of AT Com might be an intrinsic variable, and therefore its magnitude has been marked by a colon in Table 2. Unfortunately,

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we cannot verify our hypothesis, since no other bright enough comparison star falls in the CCD field of AT Com.

3. RESULTS

The light curves resulting from our observations contain an average of 100 points each, covering a significant length of time (up to five years) and are shown in the top panels of Fig.3. In the corresponding bottom panels we have plotted the residuals around the mean magnitude difference between the two brighter comparison stars of each variable. Their fair constancy shows that the chosen comparison stars are indeed non variable. No residuals are shown for AT Com since only one comparison star falls within our observational field of view. The *rms* scatter in this difference is ±0.02 mag for all stars except the comparison stars of DL Com, which show larger residuals up to 0.06 mag, because they are quite fainter than all the other objects and their photometry is undoubtedly poorer. It is interesting to note that in general the spread in the light curve is smaller than that in the corresponding residuals of the bottom panel. This is due to the fact that the variable is always the brightest star in the CCD frame (except in the case of BE Com) and its magnitude is thus measured with higher precision. Particularly striking is the case of DL Com whose light curve is very tight, despite the fact that the residuals of its comparison stars are the worst of the whole sample.

New periods for the program stars were determined using only our photometric data, by means of a period search program facility available at the Bologna Observatory, which performs a least-square estimate of frequency following the prescriptions given by Bloomfield (1976). The new periods are listed in Column 4 of Table 4. Their accuracy is $\pm$ one unit in the last digit of the listed values. Also shown in Table 4 are the new epochs of maximum light (Column 3), the amplitude of the light variation (Column 5), and the calibrated V magnitudes at maximum light (Column 6), derived from the present photometry. In the cases of uncertain maximum and/or minimum (BE Com, BS Com, CU Com, CM Leo), the quoted amplitudes correspond to the largest observed variation. Values of the corresponding quantities given by the GCVS4 are listed in Columns 7,8, and 9, for ease of comparison. To this purpose we note that the GCVS4 amplitude and magnitude at maximum light of CM Leo, CU, CY, DL, AT and BE Com are from light curves in the B filter, while for BS Com and RS Boo they are from photographic and V photoelectric data, respectively. Table 4 shows that the new periods are generally in agreement with the values published on the GCVS4 (where some of the peri-

ods reported in the previous editions of the Catalogue have been corrected). Our values are usually shorter, which is not surprising since some of these objects may have changing periods (see also remarks on the GCVS4). However, the differences do not exceed 0.00025 days, with the exception of CU Com and BS Com for which our periods are about 0.010 and 0.005 days shorter than the GCVS4 ones.

A significant discrepancy is found, instead, in the derived amplitudes of all the objects except CU Com and RS Boo. In fact, even allowing for the larger amplitude of the B light curve of an RR Lyrae with respect to its V light curve, our amplitudes are significantly smaller than those published on the GCVS4. In some cases even the pulsation mode must be changed from fundamental to first harmonic. In fact, while all the stars in Table 4 are classified as Bailey-type *ab* by the GCVS4, we have found that 3 of them look like *c*-type pulsators, and that even for BE Com, whose photometric data are more noisy, shape and amplitude of the light curve indicate that the star is more likely to pulsate in the first harmonic than in the fundamental mode. Most of the photographic light curves from which amplitudes and Bailey-types published on the GCVS4 were derived have rather poor photometric accuracy. In particular, the photographic light curves of Kurochkin (1961) and Meinunger & Wenzel (1968) are very scattered, which makes it extremely difficult to distinguish between fundamental and first harmonic pulsation mode, while the classification based on the amplitude of the light curve could also be misleading if zero point errors exist in the calibration of the plates. This effect could explain the very large discrepancy between our amplitudes and those by Meinunger & Wenzel (1968) in particular for CM Leo and AT Com (see Sections 3.1, 3.5). We will discuss these issues more in detail in Section 4.

The photometric data of the program stars are presented in Table 5 and are also available from the first author by electronic mail. For each observation we list Heliocentric Julian Day (HJD; Column 1), phase at mid exposure (Column 2), and calibrated V magnitudes (Column 3). Phases in Table 5 have been calculated according to the ephemerides given in Table 4.

3.1 CM Leonis

The light curve is shown in Fig.3a and contains 71 points observed in 9 different nights from February 19 1994 through May 21 1994. The best resulting period is 0.361479^d and the amplitude is 0.49 mag. Both the small amplitude and the symmetric shape of the light curve suggest that CM Leo is a *c*-type RR Lyrae, but the curve looks as resulting from the superposition of two well separated subcurves with ~ 0.1 mag amplitude difference. The m_{pg} light curve of this star

was published by Meinunger & Wenzel (1968): their data are very scattered and the amplitude is 1.1 mag instead of our 0.49 mag.

3.2 CU Comae

The light curve is shown in Fig.3b and contains 118 points observed in 7 different nights from January 31 1989 through April 29 1994. The best resulting period is 0.405749^d and the maximum amplitude is 0.58 mag, thus indicating that CU Com is probably a *c*-type variable. The region around maximum light appears splitted in two different branches with amplitude difference of about 0.15 mag. The m_{pg} light curve of Meinunger & Wenzel (1968) for CU Com is very poor, and has an amplitude of 0.5 mag which makes it difficult to understand why this star was classified as *ab*-type. We have a few I and R frames (9 and 6, respectively) of this object covering the phase region : $0.47 \div 0.84$, i.e. from just before minimum light to about 2/3 of the rising branch of the light curve. The corresponding uncalibrated V−R and V−I colour curves have amplitudes and shapes compatible with CU Com being a *c*-type RR Lyrae.

3.3 CY Comae

The light curve is shown in Fig.3c and contains 177 points observed in 16 different nights from March 13 1989 through April 28 1994. The best resulting period is 0.757880^d, in perfect agreement with the GCVS4 value, and the amplitude is 0.70 mag. It must be noted that this star was originally included in our sample since the $GCVS_t$ gave for it a much shorter period, $P=0.4311^d$. Despite the faintness of CY Com, the light curve is tight and well defined, showing the typical asymmetry of an *ab*-type RR Lyrae. CCD photometry in the V and R bands has recently been obtained for CY Com by Schmidt (1991) and Schmidt & Reiswig (1993). Their light curves contain 27 data points, shown in Figure 2 of Schmidt & Reiswig (1993). Their derived amplitude of the visual light variation is A_V=0.71 mag and the intensity mean magnitude is $<V>$=14.61. These values compare extremely well with our values of 0.70 and 14.62 mag, respectively. The V magnitude at minimum light read from Figure 2 of Schmidt & Reiswig (1993) is $V_{min} \sim 14.92 - 14.93$ mag and is in good agreement with our value of 14.95 mag. Schmidt's (1991) time of maximum light for CY Com is instead rather approximate, mainly because that phase is not sufficiently well covered in his observations.

3.4 DL Comae

The light curve is shown in Fig.3d and contains 94 points observed in 14 different nights from February 19 1994 through June 18 1994. The best resulting period,

0.4320590^d, is slightly shorter than that given by the GCVS4 where, however, it is specifically remarked as possibly varying. The light curve has an amplitude of 1.26 mag and the typical asymmetric shape of an *ab*-type RR Lyrae. The photographic light curve of DL Com was published by Kurochkin & Pochinok (1974) and has an amplitude of $\sim$ 1.5 mag. Taking into account the scatter and the different photometric band of their data, the two amplitudes are consistent with each other, thus suggesting that the amplitude of 2.0 mag quoted on the GCVS4 is wrong.
The agreement found for this star, as well as between our data and those of Smith & Reiswig (1993) for CY Com, points out that there may be problems in the data of Meinunger & Wenzel (1968) also for the other stars.

3.5 AT Comae

The light curve is shown in Fig.3e and contains 105 points observed in 7 different nights from February 22 1992 through April 30 1994. The best resulting period is 0.3444676^d and the amplitude is 0.62 mag. The latter value, combined with the shape of the light curve, suggests that AT Com is more probably pulsating in the first harmonic than in the fundamental mode. The scatter at minimum light suggests that the star may suffer from Blazhko effect. However, we should also recall that we have no check on the stability of our photometry of this variable, due to the presence of only one measurable comparison star in its CCD field. Therefore, we cannot completely exclude that the dispersion in the region of minimum light might be due either to photometric spread or to an intrinsic variation of the comparison star. The photographic light curve of this star was published by Meinunger & Wenzel (1968). While the shapes of the two curves are in good agreement, the amplitude derived from these previous data is about 1.0 mag larger than ours.

3.6 BE Comae

The light curve is shown in Fig.3f and contains 68 points observed from May 5 1989 through June 5 1994. The best resulting period is 0.414209^d. The curve is very symmetric and, since the amplitude is 0.58 mag, BE Com is most probably a *c*-type RR Lyrae. The spread around all the light curve may be due to the faintness of the variable. However, the small residuals between the magnitudes of the two comparison stars, which are only $\sim$0.5 mag brighter, suggests that at least part of the spread is real, although we do not have a clear explanation for it. Given the scatter of our light curve around maximum light, we have not attempted to derive a new epoch from our data and have adopted the value published on the

$GCVS_t$ (i.e. 37705.608). We suspect that a typing error affects the value of the epoch published on the GCVS4 (i.e. 37705.68). In fact, if the latter is used the maximum light of BE Com is shifted backward to phase 0.75. The photographic light curve of BE Com has been published by Meinunger & Wenzel (1968). Given the very large scatter of their data, both shape and amplitude of their light curve are compatible with BE Com being a *c*-type pulsator.

3.7 BS Comae

The light curve is shown in Fig.3g and contains 97 points observed in 13 different nights from April 12 1990 through June 18 1994. The best resulting period is 0.36296680^d and the amplitude is 0.7 mag. Smith (1990), on the basis of the hydrogen spectral type inferred from spectra of BS Com used in a ΔS analysis of the star, has reached the conclusion that BS Com is probably a *c*-type pulsator; however our light curve for the star is not symmetric. Moreover, the curve appears splitted in two branches with rather different magnitudes around the phase of maximum light. This split has no counterpart in the distribution of the magnitude residuals of the comparison stars and therefore we consider it real. Indeed, a note on the GCVS4 reports the shape of the light curve of BS Com to vary, and Kurochkin (1961) noticed that the strong variation in the light curve may be explained as due to Blazhko effect. Kurochkin light curve is very scattered, but its amplitude is in reasonably good agreement with ours. A detailed analysis of our data seems to suggest that the star is an *ab*-type variable affected by Blazhko with a periodicity of about 27-28 days.

We have acquired one spectrum of BS Com at phase 0.72. Direct images of BS Com taken just before and after the spectrum exposure confirmed that the spectral observation was exactly located at minimum light. The spectrum has resolution of about 1.4 Å and S/N $\sim$ 20, and allowed us to derive a reliable measure of the calcium K-line equivalent width and to apply the method described by Clementini et al. (1991) and recently recalibrated by Clementini et al. (1994). In this way, we derive a very low metal abundance [Fe/H]$\simeq -2.0$. Smith's (1990) spectra of BS Com were taken at phases that, according to our ephemerides, correspond to 0.90 and 0.63 respectively, and he derived from the latter, which is already at minimum light, a ΔS value of 8.2. This value also indicates that the variable is metal poor, and corresponds to [Fe/H]$=-1.67$ if the metallicity scale by Clementini et al. (1994) is adopted.

3.8 RS Bootis

This object is the only well studied one of our sample and will be described by Clementini et al. (1995) in a different context and with additional data. For our purposes, here it suffices to summarize the resulting features. RS Boo is an *ab*-type RR Lyrae (Spinrad 1959), with short period and affected by Blazhko effect with a secondary period of 537 days (Oosterhoff 1946, Szeidl 1976) or 533 days (Kanyo 1980) and a minor variation of the secondary period with a periodicity of about 58 $\div$ 62 days (Kanyo 1980). We have obtained UBVRI photoelectric light curves and CORAVEL (Baranne et al. 1979, Mayor 1985) radial velocity curves of this star. From our data we have derived an amplitude in V of 1.16 mag, and confirmed the occurrence of the Blazhko (Clementini et al. 1995). Spectra taken at minimum light indicate (Clementini et al. 1991) that [Fe/H]=−0.10 or [Fe/H]=+0.14 if the new metallicity calibration of the Ca II K line equivalent width by Clementini et al. (1994) is adopted, placing it indeed among the most metal rich RR Lyraes. The Baade-Wesselink method has been applied to this star by Jones et al. (1988) and the derived visual absolute magnitude is M_V=0.98 mag.

4. DISCUSSION AND CONCLUSIONS

The results presented in the previous sections show that the sample of eight *anomalous ab*-type RR Lyraes selected by CMT on the basis of data collected from the 1976 version of the GCVS suffer from several uncertainties. From our analysis we have found that:

a) In general our derived V_{max} magnitudes are brighter than those given by the $GCVS_t$ and GCVS4, but this difference can be simply due to the fact that these catalogues list the B or the photographic magnitudes which are generally $0.10 - 0.30$ mag fainter than the V magnitudes at the average colours of RR Lyraes. AT Com is the only exception being the m_{max} value given from GCVS4 $\sim$ 0.8 mag brighter that our V_{max}.

b) In six cases (AT Com, BE Com, BS Com, CY Com, DL Com and CM Leo) our amplitude is significantly smaller than that quoted in the $GCVS_t$ and GCVS4. Again, part of the difference can be due to the dependence of the amplitude on the observed band, the B-amplitude being usually larger (by $0.15 - 0.35$ mag) than the V-amplitude. This, for instance, could account for the difference of about 0.25 mag found between the amplitude of the V light curve of DL Com and the amplitude of the m_{pg} light curve derived by Kurochkin & Pochinok (1974), (see Section 3.4). But in general the differences are too large and should probably be ascribed on one side to the extreme difficulty in measuring with the older photographic techniques

the magnitude at minimum light of such faint objects, and on the other side to the peculiar variations in shape and amplitudes of the light curve that most of these variables exhibit. This problem is particularly relevant when we compare our data with those by Meinunger & Wenzel (1968).

c) In at least three cases (AT Com, CU Com and CM Leo, with the possible addition of BE Com), the actual pulsation seems to be in the first harmonic rather than in the fundamental mode. The light curve of BE Com is fairly noisy and anomalous and we can ascribe to this reason the misclassification of the attributed pulsation type, but the other three appear as typical *c*-type RR Lyraes. It must be noted, however, that these stars also show anomalous variations of the amplitude of their *c*-type light curves. A detailed analysis of the anomalies in the pulsational properties of these variables and of their causes is beyond the purposes of the present paper. Here we only list and discuss briefly some plausible interpretations of these "anomalies".

The scatter and the variable amplitudes of the light curves of CM Leo, AT, CU, BE and BS Com could be due to the Blazhko effect: a long term (10-200 days) periodic modulation of amplitude and/or shape of the light curve, which is superimposed to the main period variation and has been detected in roughly 30% of the known RR Lyraes (Szeidl 1988). Indeed, Kurochkin (1961) reports BS Com as possibly affected by Blazhko, and our data seem to confirm this hypothesis suggesting a Blazhko periodicity of about 27-28 days.

So far, only very few *c*-type RR Lyrae stars have been reported as affected by Blazhko (Szeidl 1976), and the actual occurrence of the phenomenon for *c*-type pulsators has not been definitely confirmed (see Smith et al. 1994). Szeidl (1988) pointed out that no RR*c* variable shows the long-term curve modulation of the classic Blazhko effect observed in the *ab*-type RR Lyraes and that probably RR_c stars showing variations in the amplitude of their light curves are rather double-mode pulsators. Double-mode RR Lyraes (RR_d) are variables that pulsate both in the fundamental and in the first harmonic mode with a beat period of about one day. These objects exhibit a very large scatter in their light curves caused by cycle-to-cycle amplitude changes. CM Leo, whose amplitude variations seem to occur on a time scale of about 1 day, could be a good candidate for double-mode pulsation.

Finally, an alternative explanation of the light curve anomalies might be that some of these stars are eclipsing binaries misclassified as RR Lyrae stars. In his photometric study of 93 poorly studied variables fainter than the tenth magni-

tude and selected from the GCVS4, Schmidt (1991) found that about 7.5% of the studied variables are erroneously classified as RR Lyrae stars on the GCVS4. Schmidt's (1991) re-classification is based on the appearance of the observed light curves, together with the comparison of the V and R light curve amplitudes, and the use of the V *vs* V−R colour-magnitude diagram. The latter is suggested by Schmidt to be a very powerful tool to distinguish the intrinsic pulsational variability from the geometrical effect of binarity. We have multicolour photometry only for CU Com, and, as mentioned in Section 3.2, it suggests that CU Com is an RR Lyrae variable. For the remaining suspected *c*-type stars we only have photometry in the V band and therefore we cannot check the location of these stars on the colour-magnitude diagram.

If the variability were produced by eclipses the supposed binary should be formed by a contact pair (because of the continuous variability of the light curve and the shortness of the period) and belong to the W UMa type. What we know on these systems and the morphology of the corresponding light curves is enough to make the hypothesis of binarity very unlikely. In Figure 4 we have plotted the data for CM Leo, AT and BE Com (the variables with a more symmetric light curve) using a period double of that derived assuming them to be pulsating stars. In doing this we have followed Schmidt's (1991) remark that the "light curves of some eclipsing binary are difficult to distinguish from Bailey type *c* RR Lyraes if a period half the correct value has been assumed". The curves have been compared with a library of contact binary light-curves computed by one of us (CM, unpublished) by means of the last released 1994 version of the Wilson and Devinney light curve synthesis code (in original form in Wilson and Devinney 1971). All the light curves have too peaked maxima and too flat and slowly growing minima to be reasonably fitted by any acceptable combination of parameters (see the *best* fit solution obtained for BE Com shown in panel 4d). The peaked maxima imply an extreme degree of contact (contact with the outer lagrangian surface) which is never observed in real contact binaries. Moreover, in contact binary curves the ratio r of the phase interval from the maximum to half curve depth to that from half depth to the minimum is typically larger than 1, i.e. the decrease in magnitude is slow moving away from maximum, for it is not due to eclipse but only to the "proximity effects" (mainly gravity darkening and the Roche deformation of the surfaces). The value of r approaches unity only for deep contact and low value of the inclination, that however drastically decreases the minimum depth.

To conclude, in the hypothesis of binarity we can only get a low quality fit of the observed data, (see Fig. 4d), with a set of system parameters rather improbable for a contact binary configuration. Even if only on a morphological basis, we are therefore oriented to discard the hypothesis.

The present data are not numerous enough, or sufficiently well distributed in time to allow us to undoubtedly assess the occurrence and, in case, to establish the periodicity of the Blazhko effect for our variables, or to distinguish between the Blazhko and double-mode pulsation. To explore the problem, further additional data in different colour bands and with appropriate time coverage are required. In particular, the identification of RR_d variables requires adequate phase coverage of the primary and secondary period of pulsation, while the identification of Blazhko objects requires the coverage of the Blazhko period that could be as long as 10-200 days. In both cases we therefore need observations that span several hours on a given night and in a few subsequent nights, as well as in several months and/or years. To this purpose appropriate monitoring of these variables is planned in future observing runs at the 1.52m telescope.

In any case, with the new data, we can reexamine the issue of possible metal rich variables at large distances from the disc raised by CMT. To this aim we have derived the minimum distance z of each object by assuming an absolute magnitude of M_V=0.6 at maximum light. This is not an accurate measure of the distance but is sufficient for our purposes. Note that the ranking of the distances from the plane coincides with that of the distances from the sun, because all the variables are located in the direction of the Galactic Pole. RS Boo is the closest variable with z=0.65 and its high metallicity is consistent with the abundances usually found at that height. The distances of the other variables range from 2.22 kpc for BS Com to 9.46 kpc for BE Com. CY Com is the farthest *ab*-type variable with a distance of 5.37 kpc and its period of 0.758^d suggests that it is a normal halo metal poor star. DL Com is therefore the only case of certain *ab*-type variable with short period and located as far as 2.66 kpc and we cannot consider this single object as evidence for a significant metal rich population at large distances from the galactic plane.

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FIGURE CAPTIONS

Figure 1 : Finding charts for CM Leo, CU Com, CY Com, DL Com, AT Com, BE Com and BS Com, respectively. The variable stars are marked by dashes, the comparison stars by the identification names. Each chart shows a region of the sky of $10' \times 10'$, north is up and east to the left.

Figure 2 : Calibration curve for data taken with the RCA CCD.

Figure 3 a,b,c,d,e,f,g : Light curves of CM Leo, CU, CY, DL, AT, BE and BS Com, respectively (upper panels). Bottom panels show the residual around the average magnitude difference between the two brighter comparison stars of each variable.

Figure 4 a,b,c,d : Light curves of (a) CM Leo, (b) AT Com and (c) BE Com, using periods doubled with respect to the values given in Table 4. Panel 4d shows the *best* fit solution of an eclipsing binary model computed for BE Com.

Table 1. – Journal of observations

Star	RA_{2000}	DEC_{2000}	N. Observations	Observed Interval[a]
CM Leo	11 56 14	21 15 32	71	9403−9494
CU Com	12 24 47	22 24 29	118	7558−9472
CY Com	12 28 20	24 57 19	177	7599−9471
DL Com	12 34 21	16 08 25	94	9403−9522
AT Com	12 45 44	18 12 11	105	8675−9473
BE Com	12 58 02	19 51 34	68	7652−9509
BS Com	13 34 40	24 16 39	97	9440−9522
RS Boo	14 33 33	31 45 14	—	—

[a] Observed Intervals are given as JD−2,440,000.

Table 2. – The comparison stars.

Comparison star	N_{GSC}	RA_{2000}	DEC_{2000}	V
C1 (CM Leo)	1277-1007	11 56 00	21 21 31	12.53
C1 (CU Com)	1664-1247	12 24 49	22 23 14	14.11
C1 (CY Com)	0011-0010	12 28 21	24 55 58	14.79
C3 (DL Com)	1201-1026	12 34 04	16 07 27	14.53
C1 (AT Com)	2144-1839	12 45 48	18 15 00	15.10:
C1 (BE Com)	0159-0159	12 58 05	19 52 52	15.17
C2 (BS Com)	0454-0454	13 34 30	24 18 56	13.91
BD +32 24 87 (RS Boo)	0753-0607	14 32 29	31 43 30	10.65

- Data for the comparison star of RS Boo are from Clementini et al 1994a.

Table 3. – The standard stars.

Star	V	B−V
84971	8.636	−0.159
101 389	9.962	0.427
101 324	9.743	1.157
+5 2468	9.348	−0.116
100340	10.117	−0.242
103 462	10.111	0.564
105 28	8.345	1.039
105 663	8.760	0.342
+2 2711	10.367	−0.162
107 544	9.037	0.401
107 347	9.443	1.296
149382	8.944	−0.281
108 702	8.208	0.559
108 1491	9.059	0.965
PG1633+099	14.396	−0.192
PG1633+099A	15.254	0.876
PG1633+099B	12.966	1.081
PG1633+099C	13.224	1.133

Table 4. – Derived quantities for the variable stars.

Star	Type	Epoch	Period	A_V	V_{max}	Period(GCVS4)	A(GCVS4)	m_{max}(GCVS4)
CM Leo	c	49403.6122	0.361479	0.49	13.47	0.361732	1.10	13.80
CU Com	c	49451.56667	0.405749	0.58	13.02	0.416091	0.50	13.10
CY Com	ab	47632.52446	0.757880	0.70	14.25	0.757881	1.10	14.40
DL Com	ab	49437.5242	0.4320590	1.26	12.72	0.4321025	2.00	12.90
AT Com	c	48675.6303	0.3444676	0.62	14.72	0.344465	1.60	13.90
BE Com		37705.608	0.414209	0.58	15.48	0.41421	0.90	15.70
BS Com		49451.60664	0.3629668	0.70	12.33	0.36350	1.20	12.40
RS Boo	ab	46948.7198	0.3773397	1.16	9.64	0.37733896	1.15	9.69

- Epoch of RS Boo is from Jones et al. 1988, Period is from Clementini *et al.* 1994a.

- Epoch of BE Com is from $GCVS_t$, (see Section 3.6).

Table 5a. V photometry for CM Leo.

HJD−2440000	ϕ	V	HJD−2440000	ϕ	V	HJD−2440000	ϕ	V
9403.5089	0.714	13.93	9434.4437	0.293	13.75	9437.3311	0.281	13.63
9403.5154	0.732	13.87	9434.4515	0.314	13.81	9437.3961	0.460	13.92
9403.5224	0.751	13.85	9434.4596	0.337	13.87	9437.4042	0.483	13.92
9403.5303	0.774	13.78	9434.4674	0.358	13.88	9437.4117	0.503	13.94
9403.5382	0.795	13.70	9434.4752	0.380	13.94	9437.4549	0.623	13.93
9403.5453	0.815	13.66	9434.4833	0.402	13.95	9437.4624	0.644	13.94
9403.5518	0.833	13.65	9435.3672	0.848	13.58	9440.4033	0.779	13.84
9403.5583	0.851	13.64	9435.3743	0.867	13.55	9440.4128	0.806	13.75
9403.5651	0.870	13.64	9435.3813	0.886	13.54	9441.3160	0.304	13.72
9403.5724	0.890	13.62	9435.3883	0.906	13.53	9441.3254	0.330	13.77
9403.5789	0.908	13.62	9435.3954	0.925	13.52	9441.3326	0.350	13.81
9403.5854	0.926	13.59	9435.4024	0.945	13.51	9441.3410	0.374	13.83
9403.5920	0.944	13.57	9435.4096	0.965	13.50	9441.3491	0.396	13.86
9403.5991	0.964	13.58	9435.4167	0.984	13.49	9441.3570	0.418	13.88
9403.6059	0.983	13.57	9435.4236	0.004	13.48	9441.3643	0.438	13.90
9403.6122	0.000	13.56	9435.4314	0.025	13.48	9441.3713	0.457	13.92
9434.3764	0.106	13.58	9436.3945	0.689	13.91	9441.3785	0.477	13.94
9434.3852	0.131	13.58	9436.4039	0.716	13.88	9442.5285	0.659	13.95
9434.3941	0.156	13.57	9436.4122	0.738	13.84	9442.5423	0.697	13.94
9434.4030	0.180	13.61	9436.4201	0.760	13.80	9442.5512	0.721	13.93
9434.4111	0.202	13.66	9436.4279	0.782	13.74	9494.3780	0.096	13.49
9434.4193	0.225	13.62	9436.4364	0.805	13.67	9494.3863	0.119	13.47
9434.4279	0.249	13.70	9436.4442	0.827	13.60	9494.3943	0.141	13.47
9434.4359	0.271	13.72	9437.3203	0.251	13.58			

Table 5b. V photometry for CU Com.

HJD−2440000	ϕ	V	HJD−2440000	ϕ	V	HJD−2440000	ϕ	V
7558.5246	0.450	13.59	7598.5897	0.194	13.27	8725.4617	0.458	13.53
7558.5399	0.488	13.61	7598.5958	0.209	13.29	8725.4644	0.465	13.54
7558.5520	0.518	13.61	7598.6024	0.225	13.30	8725.4663	0.469	13.53
7558.5780	0.582	13.60	7598.6074	0.238	13.31	8725.4679	0.473	13.54
7558.5893	0.610	13.61	7598.6128	0.251	13.33	8725.4695	0.477	13.53
7558.6149	0.673	13.57	7598.6227	0.275	13.35	8725.4710	0.481	13.56
7558.6247	0.697	13.54	7598.6293	0.292	13.38	8725.4725	0.484	13.53
7558.6280	0.705	13.53	7598.6356	0.307	13.39	8725.4744	0.489	13.54
7558.6313	0.713	13.52	7598.6402	0.318	13.40	8725.4945	0.539	13.56
7558.6347	0.722	13.50	7598.6443	0.329	13.41	8725.4973	0.545	13.57
7558.6566	0.776	13.41	7598.6485	0.339	13.42	8725.4992	0.550	13.58
7558.6614	0.788	13.39	7598.6531	0.350	13.44	8725.5007	0.554	13.57
7558.6654	0.798	13.38	7598.6573	0.361	13.44	8725.5023	0.558	13.58
7558.6691	0.807	13.37	7598.6615	0.371	13.46	8725.5042	0.563	13.58
7558.6727	0.815	13.35	7598.6662	0.382	13.46	8725.5059	0.567	13.57
7558.6854	0.847	13.33	7598.6703	0.393	13.46	8725.5080	0.572	13.58
7558.6892	0.856	13.30	7598.6745	0.403	13.48	8725.5104	0.578	13.60
7558.6927	0.865	13.28	7598.6787	0.413	13.49	8725.5119	0.582	13.59
7598.4233	0.784	13.46	7598.6837	0.426	13.50	8725.5134	0.585	13.57
7598.4287	0.797	13.43	8696.5628	0.234	13.34	8725.5142	0.587	13.59
7598.4388	0.822	13.37	8696.5672	0.245	13.35	9076.4956	0.608	13.58
7598.4485	0.846	13.32	8696.5709	0.254	13.34	9076.4972	0.612	13.59
7598.4527	0.856	13.29	8696.5743	0.262	13.36	9076.4987	0.616	13.60
7598.4571	0.867	13.28	8696.5769	0.269	13.36	9076.5000	0.619	13.59
7598.4614	0.878	13.27	8696.5796	0.275	13.35	9076.5015	0.623	13.60
7598.4659	0.889	13.25	8696.5837	0.286	13.36	9076.5029	0.626	13.60
7598.4705	0.900	13.23	8696.5865	0.293	13.37	9451.3272	0.410	13.42
7598.4753	0.912	13.23	8696.5903	0.302	13.38	9451.3360	0.431	13.43
7598.4807	0.925	13.23	8696.5987	0.323	13.38	9451.4489	0.710	13.53
7598.4872	0.941	13.21	8696.6019	0.331	13.39	9451.4571	0.730	13.51
7598.5000	0.973	13.16	8696.6045	0.337	13.41	9451.4981	0.831	13.27
7598.5066	0.989	13.15	8696.6072	0.344	13.42	9451.5069	0.853	13.18
7598.5412	0.074	13.19	8696.6100	0.350	13.41	9451.5580	0.979	13.03
7598.5486	0.093	13.19	8696.6146	0.362	13.43	9451.5667	0.000	13.02
7598.5538	0.106	13.20	8696.6174	0.369	13.43	9451.5755	0.022	13.03
7598.5583	0.117	13.20	8725.4526	0.435	13.51	9451.5843	0.043	13.04
7598.5628	0.128	13.21	8725.4550	0.441	13.50	9472.5555	0.729	13.59
7598.5695	0.144	13.23	8725.4565	0.445	13.51	9472.5656	0.753	13.58
7598.5748	0.157	13.24	8725.4579	0.448	13.51			
7598.5842	0.181	13.26	8725.4598	0.453	13.51			

Table 5c. V photometry for CY Com.

HJD−2440000	ϕ	V	HJD−2440000	ϕ	V	HJD−2440000	ϕ	V
7599.3526	0.231	14.53	7655.5339	0.360	14.66	8674.5127	0.872	14.71
7599.3608	0.242	14.55	7655.5391	0.367	14.66	8674.5182	0.880	14.65
7599.3686	0.252	14.56	7655.5462	0.376	14.68	8674.5224	0.885	14.58
7599.3763	0.262	14.57	7655.5540	0.387	14.66	8674.5266	0.891	14.52
7599.3839	0.272	14.56	7655.5632	0.399	14.69	8674.5307	0.896	14.50
7599.3915	0.282	14.59	7655.5686	0.406	14.71	8674.5349	0.902	14.47
7599.3992	0.292	14.60	7655.5831	0.425	14.73	8674.5408	0.909	14.45
7599.4072	0.303	14.61	7655.5885	0.432	14.73	8674.5429	0.912	14.47
7599.4147	0.313	14.63	7655.5945	0.440	14.73	8674.5478	0.919	14.45
7599.4369	0.342	14.67	7655.6000	0.448	14.73	8674.5512	0.923	14.44
7599.4478	0.356	14.69	7948.4220	0.817	14.94	8674.5554	0.929	14.41
7599.4554	0.366	14.67	7948.4313	0.830	14.92	8674.5582	0.932	14.40
7599.4630	0.376	14.68	7948.4395	0.840	14.89	8674.5623	0.938	14.38
7599.4705	0.386	14.70	7948.4479	0.851	14.85	8674.5658	0.942	14.36
7599.4784	0.397	14.71	7948.4566	0.863	14.79	8675.4468	0.105	14.39
7599.4859	0.407	14.75	7948.4646	0.874	14.72	8675.4517	0.111	14.39
7599.4935	0.417	14.75	7948.4730	0.885	14.61	8675.4565	0.118	14.41
7599.5011	0.427	14.74	7948.5082	0.931	14.42	8675.4614	0.124	14.41
7632.3717	0.798	14.93	7948.5165	0.942	14.38	8675.4663	0.131	14.42
7632.3836	0.814	14.93	7948.5244	0.953	14.32	8679.4186	0.346	14.65
7632.3931	0.827	14.92	7948.5324	0.963	14.29	8679.4247	0.354	14.65
7632.4009	0.837	14.86	7948.5404	0.974	14.23	8679.4316	0.363	14.65
7632.4091	0.848	14.83	7948.5488	0.985	14.27	8679.4370	0.370	14.68
7632.4175	0.859	14.80	7948.5568	0.995	14.25	8679.4430	0.378	14.68
7632.4253	0.869	14.74	7948.5653	0.006	14.26	8679.4478	0.384	14.69
7632.4330	0.879	14.65	7948.5740	0.018	14.27	8696.3854	0.733	14.95
7632.4417	0.891	14.54	7948.5820	0.028	14.28	8696.3921	0.742	14.94
7632.4497	0.901	14.48	7993.3568	0.107	14.37	8696.3973	0.748	14.94
7632.4573	0.911	14.47	7994.4026	0.487	14.76	8696.4065	0.761	14.96
7632.4942	0.960	14.31	7994.4121	0.500	14.77	8696.4107	0.766	14.96
7632.5021	0.971	14.29	7994.4218	0.513	14.77	8696.4148	0.772	14.95
7632.5089	0.979	14.27	7994.4297	0.523	14.77	8696.6345	0.061	14.34
7632.5164	0.989	14.24	7994.4376	0.534	14.78	8696.6421	0.071	14.35
7632.5245	0.000	14.25	7994.4454	0.544	14.77	8696.6464	0.077	14.36
7632.5326	0.011	14.25	7994.4536	0.555	14.79	8696.6506	0.083	14.36
7632.5420	0.023	14.25	7994.4618	0.565	14.79	8696.6560	0.090	14.37
7632.5504	0.034	14.28	7994.4706	0.577	14.80	8696.6609	0.096	14.39
7632.5584	0.045	14.29	7994.4796	0.589	14.80	8696.6652	0.102	14.39
7632.5664	0.055	14.32	7994.4883	0.600	14.82	8696.6689	0.107	14.40
7632.5743	0.066	14.31	7994.4976	0.613	14.81	8696.6728	0.112	14.40
7655.3642	0.136	14.44	7994.5063	0.624	14.82	8696.6770	0.118	14.41
7655.3738	0.149	14.46	7994.5150	0.636	14.82	8725.5315	0.190	14.49
7655.3829	0.161	14.47	7994.5230	0.646	14.84	8725.5368	0.197	14.50
7655.3910	0.172	14.48	7994.5314	0.657	14.84	8725.5409	0.202	14.50
7655.3975	0.180	14.48	7994.5392	0.668	14.86	8725.5451	0.208	14.50
7655.4035	0.188	14.49	7994.5470	0.678	14.87	8725.5491	0.213	14.51
7655.4109	0.198	14.49	7994.5565	0.690	14.89	8762.3872	0.820	14.94
7655.4208	0.211	14.52	7994.5643	0.701	14.89	8762.3918	0.826	14.93
7655.4267	0.219	14.53	7994.5732	0.712	14.91	8762.3960	0.832	14.91
7655.4630	0.267	14.55	7994.5818	0.724	14.90	8762.4005	0.838	14.90
7655.4709	0.277	14.57	7995.3636	0.755	14.94	9436.4613	0.241	14.50
7655.4817	0.291	14.57	7995.3719	0.766	14.95	9436.4707	0.253	14.51

7655.5060	0.323	14.62	8674.4891	0.841	14.86	9436.5804	0.398	14.67
7655.5119	0.331	14.62	8674.4988	0.854	14.82	9436.6460	0.484	14.74
7655.5177	0.339	14.62	8674.5030	0.859	14.78	9442.4602	0.156	14.42
7655.5243	0.348	14.64	8674.5078	0.866	14.76	9471.4730	0.438	14.69

Table 5d. V photometry for DL Com.

HJD−2440000	ϕ	V	HJD−2440000	ϕ	V	HJD−2440000	ϕ	V
9403.6371	0.568	13.85	9435.4480	0.195	13.32	9440.5619	0.031	12.80
9403.6517	0.602	13.83	9435.4550	0.211	13.36	9441.4799	0.156	13.22
9403.6591	0.619	13.84	9435.4620	0.227	13.41	9441.4875	0.173	13.26
9403.6657	0.635	13.85	9435.4723	0.251	13.44	9441.5155	0.238	13.40
9403.6734	0.652	13.84	9435.4795	0.268	13.47	9441.5238	0.257	13.44
9403.6813	0.671	13.85	9435.4865	0.284	13.51	9441.5307	0.273	13.47
9403.6885	0.687	13.86	9435.4936	0.300	13.54	9441.5382	0.290	13.50
9403.6960	0.705	13.86	9435.5007	0.317	13.55	9441.5498	0.317	13.55
9403.7034	0.722	13.85	9435.5077	0.333	13.58	9441.5586	0.337	13.60
9403.7107	0.739	13.85	9435.5151	0.350	13.61	9441.5683	0.360	13.61
9406.4884	0.168	13.27	9435.5225	0.367	13.63	9441.5752	0.376	13.65
9406.4975	0.189	13.32	9435.5296	0.384	13.68	9441.5868	0.403	13.69
9406.5045	0.205	13.37	9435.5372	0.401	13.70	9441.5945	0.421	13.73
9406.5128	0.224	13.40	9435.5442	0.417	13.72	9441.6022	0.438	13.75
9406.5209	0.243	13.42	9435.5512	0.434	13.75	9441.6119	0.461	13.79
9406.5315	0.267	13.48	9435.5583	0.450	13.76	9442.4148	0.319	13.54
9434.5087	0.021	12.80	9435.5654	0.466	13.78	9442.4372	0.371	13.64
9434.5178	0.042	12.82	9435.5855	0.513	13.81	9442.5146	0.550	13.79
9434.5256	0.060	12.87	9435.5924	0.529	13.81	9465.5333	0.827	13.95
9434.5339	0.079	12.95	9436.5989	0.858	13.98	9465.5415	0.846	13.96
9434.5417	0.097	13.00	9436.6080	0.880	13.95	9465.5502	0.866	13.97
9434.5510	0.119	13.06	9436.6162	0.899	13.85	9465.5584	0.885	13.93
9434.5590	0.137	13.10	9436.6241	0.917	13.63	9473.4336	0.112	13.08
9434.5668	0.155	13.18	9436.6319	0.935	13.28	9473.4427	0.133	13.15
9434.5746	0.173	13.21	9437.4870	0.914	13.76	9473.4779	0.215	13.35
9434.5823	0.191	13.25	9437.4951	0.933	13.36	9473.4863	0.234	13.38
9434.5902	0.209	13.30	9437.5022	0.949	13.15	9510.3668	0.594	13.79
9434.5980	0.227	13.35	9437.5098	0.967	12.84	9520.3565	0.715	13.89
9434.6061	0.246	13.40	9437.5290	0.011	12.74	9522.3896	0.421	13.72
9434.6140	0.264	13.43	9440.4258	0.716	13.83	9522.3982	0.441	13.74
9434.6218	0.282	13.45	9440.4344	0.736	13.82			
9434.6297	0.301	13.49	9440.5528	0.010	12.72			

Table 5e. V photometry for AT Com.

HJD−2440000	ϕ	V	HJD−2440000	ϕ	V	HJD−2440000	ϕ	V
8675.4911	0.596	15.30	8675.6765	0.134	14.85	8725.3204	0.252	15.01
8675.4977	0.615	15.34	8675.6799	0.144	14.86	8725.3244	0.264	14.98
8675.5032	0.631	15.34	8675.6852	0.159	14.88	8725.3285	0.275	15.03
8675.5077	0.644	15.34	8675.6890	0.170	14.90	8725.3625	0.374	15.14
8675.5136	0.661	15.34	8675.6935	0.183	14.91	8725.3672	0.388	15.16
8675.5178	0.673	15.32	8675.6973	0.195	14.94	8725.3714	0.400	15.16
8675.5234	0.690	15.32	8675.7015	0.207	14.92	8725.3754	0.412	15.21
8675.5275	0.702	15.34	8696.4350	0.397	15.15	8725.3808	0.427	15.22
8675.5331	0.718	15.30	8696.4431	0.420	15.18	8725.3859	0.442	15.24
8675.5383	0.733	15.28	8696.4485	0.436	15.20	8725.3914	0.458	15.25
8675.5466	0.757	15.28	8696.4545	0.453	15.22	8725.3967	0.473	15.28
8675.5511	0.770	15.28	8696.4594	0.468	15.21	8725.4016	0.488	15.26
8675.5560	0.784	15.21	8696.4653	0.485	15.26	8725.4069	0.503	15.31
8675.5629	0.804	15.17	8696.4693	0.496	15.27	8725.4116	0.517	15.31
8675.5699	0.825	15.08	8696.4754	0.514	15.29	8725.5753	0.992	14.73
8675.5754	0.841	15.01	8696.4803	0.528	15.33	8725.5810	0.008	14.72
8675.5806	0.856	14.94	8696.4862	0.545	15.31	8725.5860	0.023	14.75
8675.5848	0.868	14.89	8696.4915	0.561	15.30	8725.5907	0.037	14.77
8675.5897	0.882	14.87	8696.4963	0.575	15.33	8725.5954	0.050	14.78
8675.5938	0.894	14.84	8696.5014	0.589	15.31	8725.6001	0.064	14.78
8675.5983	0.907	14.80	8696.5086	0.610	15.30	8725.6048	0.077	14.78
8675.6056	0.928	14.78	8696.5150	0.629	15.29	8725.6095	0.091	14.80
8675.6105	0.943	14.78	8696.5211	0.647	15.29	9076.5765	0.959	14.74
8675.6157	0.958	14.76	8696.5265	0.662	15.28	9076.5792	0.967	14.72
8675.6240	0.982	14.75	8696.5321	0.679	15.27	9076.5820	0.975	14.73
8675.6303	1.000	14.72	8696.5371	0.693	15.29	9076.5849	0.983	14.71
8675.6345	0.012	14.73	8696.5419	0.707	15.27	9076.5872	0.990	14.72
8675.6397	0.027	14.74	8696.5467	0.721	15.27	9076.5897	0.998	14.71
8675.6438	0.039	14.74	8704.4717	0.728	15.28	9436.5115	0.861	14.92
8675.6484	0.052	14.76	8704.4768	0.742	15.26	9436.5255	0.902	14.81
8675.6525	0.065	14.77	8704.4814	0.755	15.19	9436.5369	0.935	14.76
8675.6574	0.079	14.79	8704.4860	0.769	15.20	9436.6659	0.310	15.02
8675.6619	0.092	14.79	8704.4906	0.782	15.21	9473.5227	0.306	14.99
8675.6661	0.104	14.82	8725.3100	0.222	14.95	9473.5339	0.339	15.02
8675.6716	0.120	14.84	8725.3163	0.240	14.98	9473.5450	0.371	15.07

Table 5f. V photometry for BE Com.

HJD−2440000	ϕ	V	HJD−2440000	ϕ	V	HJD−2440000	ϕ	V
7652.4046	0.956	15.53	9076.4724	0.997	15.48	9465.5060	0.218	15.79
7652.4148	0.980	15.55	9076.4767	0.008	15.48	9471.4736	0.625	16.01
7652.4303	0.018	15.50	9076.4806	0.017	15.48	9473.3896	0.251	15.73
7652.5577	0.325	15.96	9076.4850	0.028	15.47	9473.4005	0.277	15.78
7652.5808	0.381	16.03	9076.5253	0.125	15.61	9473.4103	0.301	15.82
7653.4723	0.533	16.06	9076.5289	0.134	15.61	9473.4203	0.325	15.89
7653.4914	0.579	16.08	9076.5327	0.143	15.63	9473.4548	0.408	16.01
7654.3573	0.670	16.00	9076.5366	0.152	15.65	9473.4649	0.433	16.03
7654.3704	0.702	16.01	9076.5404	0.162	15.66	9473.5079	0.536	15.98
7654.3864	0.740	15.98	9076.5452	0.173	15.67	9487.4772	0.262	15.94
7654.4044	0.784	15.92	9076.5491	0.183	15.70	9508.4373	0.865	15.54
7654.4665	0.934	15.52	9076.6007	0.307	15.93	9508.4471	0.888	15.56
7654.4964	0.006	15.55	9076.6047	0.317	15.95	9508.4568	0.911	15.58
7654.5190	0.060	15.63	9076.6125	0.336	16.00	9508.4679	0.938	15.60
9076.4233	0.879	15.69	9076.6171	0.347	16.00	9508.4783	0.963	15.64
9076.4260	0.885	15.66	9076.6208	0.356	16.00	9509.4259	0.251	15.85
9076.4290	0.893	15.61	9076.6247	0.365	16.00	9509.4378	0.280	15.94
9076.4324	0.901	15.58	9076.6285	0.374	16.02	9509.4478	0.304	15.97
9076.4355	0.908	15.52	9437.3612	0.270	15.69	9509.4577	0.328	16.02
9076.4389	0.917	15.51	9437.5440	0.711	15.96	9509.4674	0.351	15.99
9076.4421	0.924	15.50	9437.5622	0.755	16.06	9509.4782	0.377	16.00
9076.4622	0.973	15.51	9465.4291	0.032	15.50	9509.4868	0.398	16.06
9076.4678	0.986	15.49	9465.4711	0.134	15.66			

Table 5g. V photometry for BS Com.

HJD−2440000	ϕ	V	HJD−2440000	ϕ	V	HJD−2440000	ϕ	V
9440.5769	0.612	13.01	9465.4527	0.147	12.66	9492.4338	0.482	12.96
9440.5875	0.641	13.01	9465.4592	0.165	12.67	9492.4440	0.510	12.99
9440.5979	0.670	13.01	9465.4878	0.244	12.73	9492.4569	0.545	12.99
9440.6091	0.701	13.02	9465.4949	0.263	12.74	9492.4648	0.567	13.00
9440.6193	0.729	13.00	9465.5686	0.466	12.94	9492.4770	0.601	13.02
9440.6630	0.849	13.01	9465.5765	0.488	12.95	9492.4909	0.639	13.02
9441.6424	0.548	13.03	9465.5816	0.502	12.98	9492.5018	0.669	13.04
9441.6519	0.574	13.03	9465.5889	0.522	13.00	9492.5121	0.697	13.04
9441.6613	0.600	13.05	9465.5988	0.549	13.01	9492.5225	0.726	13.03
9442.6545	0.336	12.87	9465.6059	0.569	13.02	9492.5341	0.758	13.00
9451.3545	0.305	12.83	9465.6139	0.591	13.02	9492.5448	0.788	12.98
9451.3633	0.330	12.87	9465.6224	0.614	13.03	7994.5992	0.838	12.97
9451.4265	0.504	13.05	9465.6302	0.636	13.03	7994.6223	0.902	12.67
9451.4374	0.534	13.06	9465.6383	0.658	13.04	7994.6270	0.915	12.62
9451.4729	0.631	13.10	9471.3461	0.384	12.81	7994.6331	0.932	12.58
9451.4824	0.658	13.11	9471.3555	0.409	12.82	7994.6392	0.949	12.55
9451.5344	0.801	12.99	9471.3648	0.435	12.85	7994.6419	0.956	12.52
9451.5460	0.833	12.90	9471.3762	0.467	12.90	7994.6472	0.971	12.51
9451.5987	0.978	12.34	9471.3848	0.490	12.92	7994.6499	0.978	12.49
9451.6066	1.000	12.34	9471.4092	0.557	13.00	9508.4051	0.484	12.91
9451.6136	0.019	12.35	9471.4178	0.581	13.02	9508.4176	0.518	12.95
9451.6198	0.036	12.34	9471.4511	0.673	13.03	9511.3458	0.586	12.99
9451.6267	0.055	12.36	9471.4906	0.782	13.02	9511.3636	0.635	13.07
9451.6329	0.072	12.38	9471.4988	0.804	13.03	9511.4340	0.829	13.06
9451.6394	0.090	12.41	9471.5379	0.912	12.70	9511.4511	0.876	13.04
9451.6461	0.109	12.43	9471.5501	0.946	12.55	9511.4578	0.894	13.02
9465.3622	0.898	12.52	9487.4908	0.864	12.99	9519.3776	0.714	12.99
9465.3741	0.930	12.49	9492.3569	0.270	12.76	9519.4472	0.906	12.44
9465.3871	0.966	12.48	9492.3710	0.309	12.79	9519.4554	0.928	12.43
9465.3947	0.987	12.50	9492.3820	0.339	12.81	9522.4136	0.078	12.39
9465.4033	0.011	12.52	9492.3920	0.367	12.83	9522.4228	0.104	12.42
9465.4103	0.030	12.53	9492.4066	0.407	12.86			
9465.4458	0.128	12.63	9492.4224	0.450	12.92			